PH 220 Homework Assignment Chapter on Angular Momentum – 21 Problems Total

1. Consider a uniform cylindrical grinding wheel which has a mass (3.45 kg). It has a radius $(\text{R} = 0.230 \text{ m})$. It is rotating at $1500. \text{rpm}$.

(a) What is the angular momentum of the grinding wheel?

(b) How much torque is required to bring the wheel to rest in 7.60 s?

Solution for Problem 1

2. An Olympic figure skater is initially doing a spin move with a rotation rate of $1.57 \ {}^{\text{rad}}/_{\text{s}}$. By reducing her moment of inertia (usually by bringing her arms closer to her rotation axis), she increases her spin rate to $5.11 \ {}^{\text{rad}}/_{\text{s}}$. If her moment of inertia was initially 4.75 kg m^2, what is her final moment of inertia?

Solution for Problem 2

3. A competitive diver can reduce his moment of inertia by tightening his tuck. If the diver is initially rotating with an angular speed of $8.38 \ {}^{\text{rad}}/_{\text{s}}$, while his moment of inertia is 9.36 kgm^2, what is his angular speed if he reduces his moment of inertia to 6.86 kgm^2?

Solution for Problem 3

4. The Earth has a mass $(\text{m}_\text{E} = 5.98 \text{ x } 10^{24}\text{kg})$, a radius $(\text{R}_\text{E} = 6.38 \text{ x } 10^{6} \text{ m})$, and radius around the Sun $(\text{R}_{\text{ES}} = 1.50 \text{ x } 10^{11} \text{ m})$. Determine the angular momentum of the Earth in the following cases:

(a) Consider the Earth a uniform sphere and it is rotating around its internal rotation axis once per day.

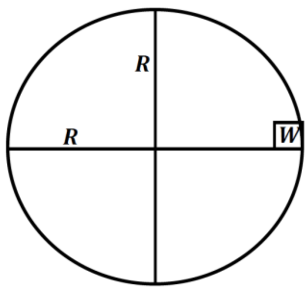
(b) Consider the Earth an orbiting object going around the Sun once a year.

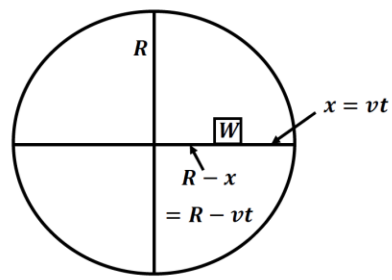
Solution for Problem 4

5. A potter's wheel can be considered as a thin disk that rotates about its center. The wheel has a radius $(R_W = 0.300 \text{ m})$ and a mass $(m_W = 10.0 \text{ kg})$. A piece of clay in the shape of a thin disk is dropped onto the center of the wheel. The clay has a mass $(m_C = 3.80 \text{ kg})$ and a radius $(R_C = 0.145 \text{ m})$. The wheel was making $2.00 \text{ Rev}/_\text{s}$ before the clay was dropped onto it. What is the final number of revolutions per second after the clay is stuck onto the center of the wheel?

<u>**Solution for Problem 5**</u>

6. A woman who has a mass (m_W) stands on the edge of a rotating platform which can be considered a solid disk. The disk has mass (m_D) and a radius (R_D). At time $t = 0.00 \text{ s}$, the platform is rotating with an angular speed (ω_0) on a frictionless bearing about an axis going through the center of the disk. The woman who has been at rest until this time begins walking with a speed (v) along a radius line towards the center of the disk.





(a) Find an expression that provides angular velocity as a function of time.

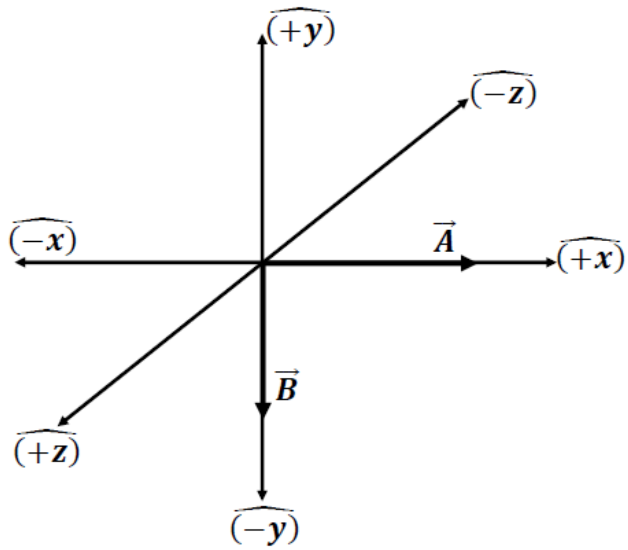
(b) Determine the angular speed when the woman reaches the center of the platform.

<u>**Solution for Problem 6**</u>

7. A disk has a mass (m) and a radius (R) and it is rotating around the axis that passes through its center of mass vertically with an angular speed (ω_0). A ring with the same mass (m) and radius (R) placed onto the disk so that their center of masses lies on this same axis that the disk was rotating around. Assuming the ring is lowered and placed onto the disk with no external torque resulting, what is the final angular speed of the combination of ring and disk?

<u>**Solution for Problem 7**</u>

8. Vector $\vec{A}$ points along the positive x axis and vector $\vec{B}$ points along the negative y axis as illustrated below.



(a) What is the direction of Vector $\vec{C} = \vec{A} \times \vec{B}$?

(b) What is the direction of Vector $\vec{D} = \vec{B} \times \vec{A}$?

(c) What is the magnitude of Vector $\vec{C} = \vec{A} \times \vec{B}$?

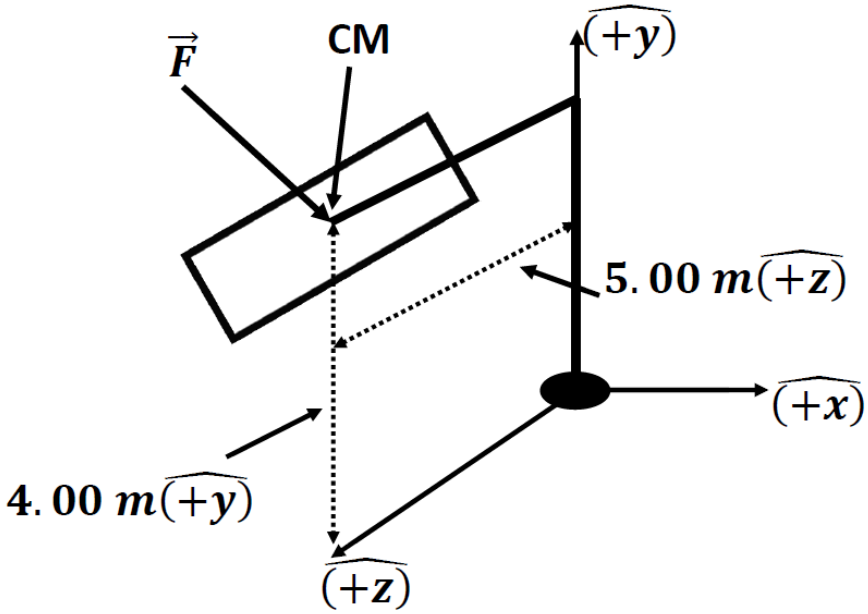
(d) What is the magnitude of Vector $\vec{D} = \vec{B} \times \vec{A}$?

Solution for Problem 8

9. What is the angle (θ_{AB}) between two vectors $\vec{A}$ and $\vec{B}$ if $|\vec{A} \times \vec{B}| = \vec{A} \cdot \vec{B}$?

Solution for Problem 9

10. The Center of Mass of highway sign sits $4.00\ \text{m}$ in the positive y direction and $5.00\ \text{m}$ along the positive z direction as shown below. A force $\vec{F} = +6.00 \times 10^3\ \text{N}\ \widehat{(\imath)} - 7.00 \times 10^3\ \text{N}\ \widehat{(\jmath)}$ acts on the center of mass as indicated. What is the magnitude of the torque at the origin of the coordinate system which is the base of the sign where it enters the ground?

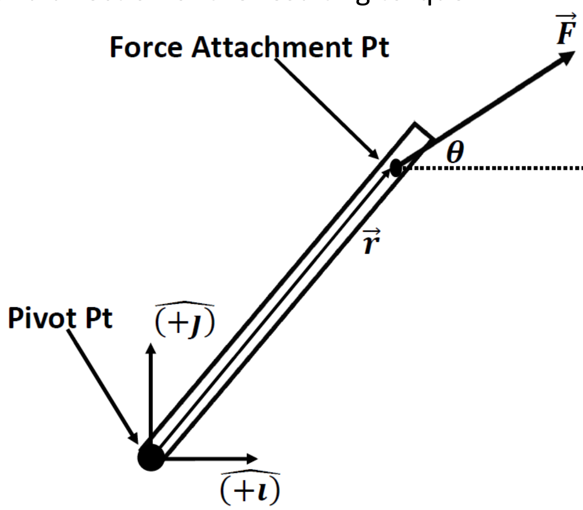


<u>Solution for Problem 10</u>

11. A long thin rod has a hinge on one end about which in the xy plane the rod is free to rotate. At an attachment point located from the rotation point by

$$\vec{r} = 0.280\ \text{m}\ (\widehat{\imath}) + 0.335\ \text{m}\ (\widehat{\jmath})$$

At the attachment point a force is applied $\vec{F} = 220.\ \text{N}\ @\ 33.0°\ \text{above}\ \widehat{(+\imath)}$ as shown below. What is the magnitude and direction of the resulting torque?



<u>Solution for Problem 11</u>

12. Find the x, y, and z components of the angular momentum of a particle located at

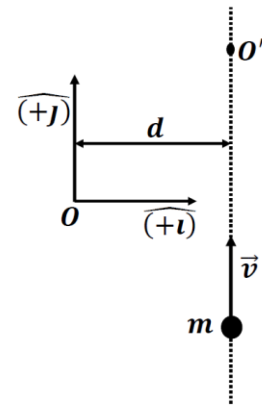
$$\vec{r} = x\ (\widehat{\imath}) + y\ (\widehat{\jmath}) + z\ (\widehat{k})$$

Which has a momentum given by:

$$\vec{p} = p_x\ (\widehat{\imath}) + p_y\ (\widehat{\jmath}) + p_z\ (\widehat{k})$$

<u>Solution for Problem 12</u>

13. A particle of mass (m) is traveling along a straight line with a constant velocity $(\vec{\mathrm{v}})$ at a distance (d) from the y axis. This is illustrated in the figure on the right.



(a) Determine the angular momentum of the particle relative to the origin O.

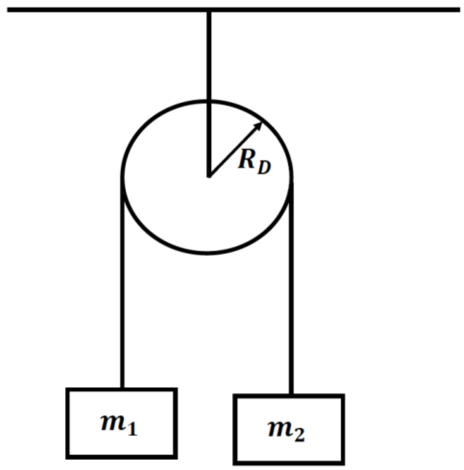
(b) Determine the angular momentum of the particle relative to the point O' shown in the figure on the right.

Solution for Problem 13

14. Calculate the angular momentum of a particle $(\mathrm{m} = 3.76\ \mathrm{kg})$ relative to the origin of the coordinate system when the particle is at location $(3.67\ \mathrm{m}, -5.77\ \mathrm{m}, -8.12\ \mathrm{m})$ and possesses a velocity of $\vec{\mathrm{v}} = -2.23\ \mathrm{m}/\mathrm{s}\ (\hat{\imath}) + 4.98\ \mathrm{m}/\mathrm{s}\ (\hat{\jmath}) + 3.07\ \mathrm{m}/\mathrm{s}\ (\hat{\mathrm{k}})$.

Solution for Problem 14

15. Pictured below is an "Atwood's Machine" which consists of two masses $(\mathrm{m_1} = 9.11\ \mathrm{kg}$ and $\mathrm{m_2} = 7.11\ \mathrm{kg})$ which are connected by a massless, stretchless and unbreakable cord which then sits on a pulley which can be considered a uniform solid cylinder with a mass $(\mathrm{m_D} = 0.965\ \mathrm{kg})$ and a radius $(\mathrm{R_D} = 0.273\ \mathrm{m})$. The pulley is supported by a beam which is attached to a ceiling a above it. Ignore any friction or air resistance forces.



(a) Determine the acceleration of mass 1.

(b) Determine the acceleration of mass 2.

(c) Determine the angular acceleration of the cylinder.

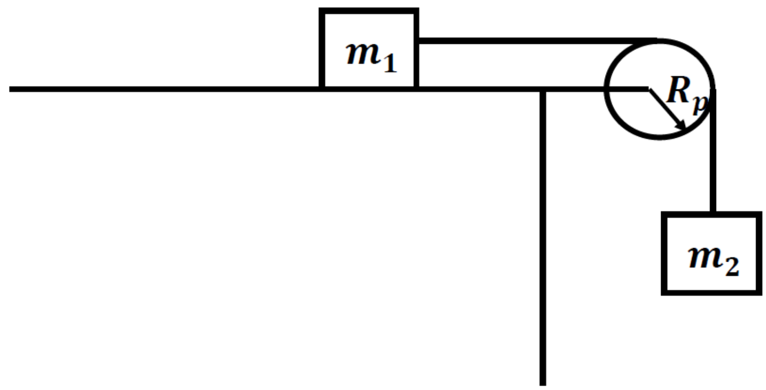
(d) Determine the tension in the cord touching mass 1.

(e) Determine the tension in the cord touching mass 2.

(f) Determine the percentage change in the value for the acceleration of mass 1 if the moment of inertia of the pulley was ignored.

<u>Solution for Problem 15</u>

16. Shown below two masses ($m_1 = 8.51$ kg and $m_1 = 7.19$ kg) are connected by a massless, stretchless and unbreakable cord. The horizontal surface that m_a slides on is frictionless. The cord passes over a pulley which is made from a solid disk ($m_P = 1.64$ kg and $R_P = 0.198$ m) which has a frictionless bearing that it turns about

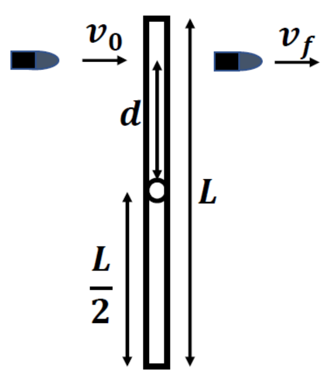


(a) Find an expression relating the angular momentum of the two masses and pulley system as a function of the speed of the blocks (v).

(b) Calculate the acceleration of the masses.

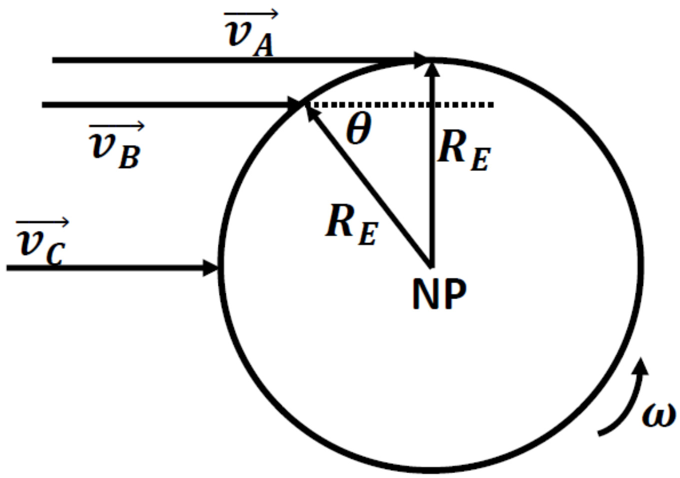
Solution for Problem 16

17. A wooden board is initially at rest with a hinge at its center about which it can rotate in a vertical plane as shown below. The length of the board is ($L = 1.50$ m) and it has a mass ($m_{Board} = 0.480$ kg). A bullet ($m_{Bullet} = 0.0050$ kg) is traveling with an initial speed ($v_0 = 300.\ ^{m}/_{s}$) strikes the board a distance ($d = 0.650$ m) from the hinge, and exits the board with a final speed ($v_f = 180.\ ^{m}/_{s}$). What is the final angular speed of the board after the collision with the bullet leaves it spinning about the hinge?



Solution for Problem 17

18. The Earth has a mass $(m_E = 5.98 \text{ x } 10^{24} \text{ kg})$ and a radius $(R_E = 6.38 \text{ x } 10^6 \text{ m})$. The Earth rotates about an axis between the North and South poles with a rotation rate of $\left(\omega = 1 \ {}^{\text{Rev}}/_{\text{day}}\right)$ in a direction counter-clockwise from above the North Pole. Consider a meteorite with a mass $(m_{met} = 7.92 \text{ x } 10^{12} \text{ kg})$ and a velocity $(v = 4.14 \text{ x } 10^4 \ {}^{m}/_{s})$ striking the Earth at the Equator at points A, at an angle of $90°$ to the radius of the Earth, B, at some in between angle θ with the radius of the Earth, or at point C where it makes an angle $0°$ with respect the radius of the Earth. At which point and by how much will there be a fractional change $\frac{\Delta\omega}{\omega}$ in the Earth's angular speed? Assume the meteorite remains stuck to the Earth after the collision. $\omega = \omega_0$.



Solution for Problem 18

19. A demonstration apparatus is a nearly frictionless rotating platform. The platform has a moment of inertia of 1480 kg m^2 and a radius of 1.75 m. It is rotating with an angular speed of $1.85 \ {}^{\text{rad}}/_{\text{s}}$. When the professor steps onto the platform along a radius line and stands at the edge of the platform, the platform slows to an angular speed of $1.63 \ {}^{\text{rad}}/_{\text{s}}$. What is the mass of the professor?

Solution for Problem 19

20. A projectile with a mass (m) is launched from the ground and follows a path given by

$$\vec{r} = (v_{0x}t)\widehat{(\imath)} + \left(v_{0y}t - \frac{1}{2}gt^2\right)\widehat{(\jmath)}$$

Where v_{0x} and v_{0y} are the initial velocities in the x and y directions respectively. g is the acceleration due to gravity. The launch point is the origin of the coordinate system.

(a) Determine the torque acting on the projectile about the origin using

$$\vec{\tau} = \vec{r} \times \vec{F}$$

(b) Determine the torque acting on the projectile about the origin using

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

Solution for Problem 20

21. Consider a star with eight times our Sun's mass$(m_{Sun} = 1.99 \times 10^{30}\ kg)$ but has the same radius as our Sun$(R_{Sun} = 6.96 \times 10^{8}\ m)$. This star rotates so that it makes one revolution every nine days. If the star were to undergo a gravitational collapse to a neutron star with a radius$(R_{Neutron\ Star} = 1.20 \times 10^{4}\ m)$, losing three quarters of its mass in the process. Assume that the stars are uniform spheres at all times.

(a) Determine the rotation speed of the Neutron Star if the thrown off mass carries away no angular momentum.

(b) Determine the rotation speed of the Neutron Star if the thrown off mass carries away it share of the angular momentum (i.e. $\frac{3}{4}$ of initial angular momentum).

Solution for Problem 21

Please send any comments or questions about this page to ddonovan@nmu.edu

This page last updated on April 17, 2024